

Tutorial Sheet No. 3
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**Exercise 1**

Show how the operator **And** can be obtained from the operators **Or** and **Not**. The same goes for the operator **Or** with the operators **And** and **Not**.

**Exercise 2**

Using truth tables show that:

- $A \oplus B = A \cdot \bar{B} + \bar{A} \cdot B$
- $A \oplus B = (A+B) \cdot (\bar{A} + \bar{B})$

**Exercise 3**

Show that:

- $A + (\bar{A} \cdot B) = A + B$
- $A \cdot (\bar{A} + B) = A \cdot B$

**Exercise 3**

Determine the complement of the expression  $A + \bar{B} \cdot C$

**Exercise 5**

Show that the two associativity rules are dual, i.e. show that from the associativity rule of the operator Or, we can deduce, using de Morgan's laws, the associativity of the operator and (and inversely).

**Exercise 6**

Simplify the following logical expressions as much as possible:

- $\bar{A} \cdot B + A \cdot B$
- $(A+B) \cdot (A+\bar{B})$
- $A + A \cdot B$
- $A \cdot (A+B)$
- $\overline{A \cdot B + A + B + C + D}$
- $A + B \cdot \bar{C} + A \cdot (\overline{B \cdot C}) \cdot (A \cdot D + B)$
- $(A \oplus B) \cdot B + A \cdot B$
- $A + \bar{A} \cdot B + \bar{A} \cdot \bar{B}$

**Exercise 7**

Show that any function with three variables  $F(A, B, C)$  is equal to:

$$F(A, B, C) = A \cdot F(1, B, C) + \bar{A} \cdot F(0, B, C)$$

**Exercise 8**

Show that de Morgan's laws extend to any number of variables.

**Exercise 9**

Consider the function defined by the truth table below:

$ABC$	$F(ABC)$
0 0 0	0
0 0 1	1
0 1 0	1
0 1 1	0
1 0 0	1
1 0 1	1
1 1 0	1
1 1 1	1

1. Generate a corresponding logical expression:
  - a) in the form of sums of products;
  - b) in the form of products of sums.
2. Simplify the two expressions using the rules of Boolean algebra.
3. Construct the Karnaugh Map and determine an associated logical expression

**Exercise 10**

Consider the following logical functions. For each of them,

- construct the Karnaugh Map;
- use the diagram to simplify expressions.
- $F_1(A, B, C) = A \cdot \bar{B} \cdot C + A \cdot B \cdot \bar{C} + A \cdot B \cdot C$
- $F_2(A, B, C) = \bar{A} \cdot \bar{B} \cdot \bar{C} + A \cdot \bar{B} + A \cdot B \cdot C$
- $F_3(A, B, C) = \bar{A} \cdot \bar{B} + \bar{A} \cdot B \cdot \bar{C} + \bar{B} \cdot \bar{C} + A \cdot \bar{B} \cdot C$
- $F_4(A, B, C, D) = B \cdot \bar{C} \cdot \bar{D} + \bar{A} \cdot B \cdot \bar{D} + A \cdot B \cdot C \cdot \bar{D}$
- $F_5(A, B, C, D) = \bar{A} + A \cdot B + A \cdot \bar{B} \cdot C + A \cdot \bar{B} \cdot C \cdot D$
- $F_6(A, B, C, D) = \bar{A} \cdot \bar{B} \cdot \bar{D} + \bar{A} \cdot \bar{C} \cdot \bar{D} + \bar{A} \cdot B \cdot C \cdot \bar{D} + A \cdot B \cdot D + \bar{B} \cdot \bar{C} \cdot \bar{D} + A \cdot \bar{B} \cdot C \cdot \bar{D}$